MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2016/2017

EPM4086 – DIGITAL CONTROL SYSTEMS

(RE)

3 MARCH 2017
9.00 a.m – 11.00 a.m
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This Question paper consists of 6 pages with 4 Questions only.
2. Attempt **FOUR** out of **FOUR** questions. All questions carry equal marks and the distribution of the marks for each question is given.
3. Please write all your answers in the Answer Booklet provided.
4. Table of Transform Pairs has been included in Appendix.

Question 1

(a) What is "Digital to Analog Converter" ? [3 marks]

(b) Find the z-transform of the following functions.

(i) $F(s) = \dfrac{15}{s(s^2+16)}$ [5 marks]

(ii) $F(s) = \dfrac{8}{s^2(s+5)}$ [5 marks]

(c) Given the difference equation as

$$x(k+2) + 3x(k+1) + 2x(k) = e(k)$$

Where $x(0) = 1, x(1) = -1$, and

$$e(k) = \begin{cases} 1, k = 0 \\ 0, \ otherwire \end{cases}$$

(i) Solve for $x(k)$ as a function of k. [6 marks]

(ii) Evaluate $x(0), x(1), x(2)$ and $x(3)$ in part (i). [3 marks]

(iii) Verify the results in part (ii) using power series method. [3 marks]

Continued ...

Question 2

(a) In the digital control system, define the following

(i) Bounded-input-bounded-output stability [2 marks]

(ii) Zero-Input Stability [2 marks]

(b) Consider the characteristic equation of a discrete-time control system given by

$F(z) = z^3 - 1.5z^2 + 1.75z - 0.6 = 0$

(i) Transforming z into the r-domain [3 marks]

(ii) Apply Routh Table to check the stability [3 marks]

(c) Figure Q2 shows the block diagram of the servo control system and $\boldsymbol{D(z) = 1}$. Find the transfer function of the closed loop system with sampling period $\boldsymbol{T = 0.25}$ second. [15 marks]

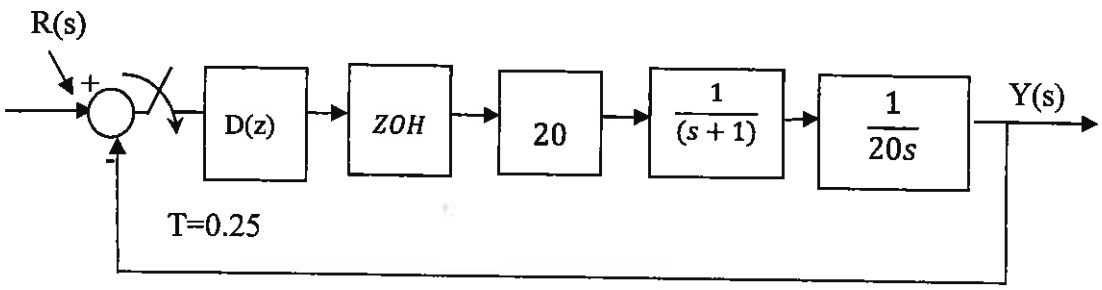

Figure Q2

Continued ...

Question 3

(a) For the discrete-time system modeled by the following dynamic equations.

$$x(k+1) = Ax(k) + Bu(k)$$
$$y(k) = Cx(k)$$

where $A = \begin{bmatrix} 1 & 1 \\ 0.5 & 4 \end{bmatrix}$, $B = \begin{bmatrix} 1 \\ -1 \end{bmatrix}$, $C = [1 \quad 1]$

(i) Determine the transfer function $Y(z)/U(z)$. [7 marks]

(ii) Design the state diagram of the system. [8 marks]

(b) Satellites apply attitude control to allow antennas, sensors, and solar panels to be properly oriented. To have an insight about the three-axis attitude control system, we consider one axis at a time as shown in Figure Q3. The angle θ describes the satellite orientation and always measures with respect to an inertia reference. The control signal comes from the reaction jets which can produce a torque $T(t) = Fd$ with respect to the mass center. The satellite is assumed to be in frictionless environment with $T(t)$ as the system input and $\theta(t)$ as the system output. Design control law to stabilize the satellite control system with settling time equal to 2 seconds and damping ratio = 0.707. [10 marks]

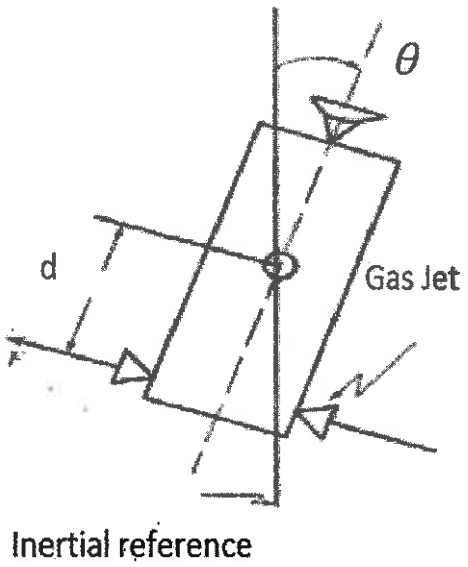

Figure Q3

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Question 4

(a) Describe the "deadbeat control law" [6 marks]

(b) A system has the plant as

$$x(k+1) = \begin{bmatrix} 2 & -1 \\ -1 & 1 \end{bmatrix} x(k) + \begin{bmatrix} 4 \\ 3 \end{bmatrix} u(k); \quad y(k) = [1 \quad 1]x(k) + 7u(k)$$

Design a state-feedback control $u(k) = -kx(k)$ which places the closed loop characteristic roots at $\pm j\frac{1}{2}$. [11 marks]

(c) The block diagram of a digital control system is shown in Figure Q4. Apply the Jury stability criterion to determine the range of value where $\boldsymbol{k > 0}$ can have a stable response. Show how these values can be affected by the sampling period T. [8 marks]

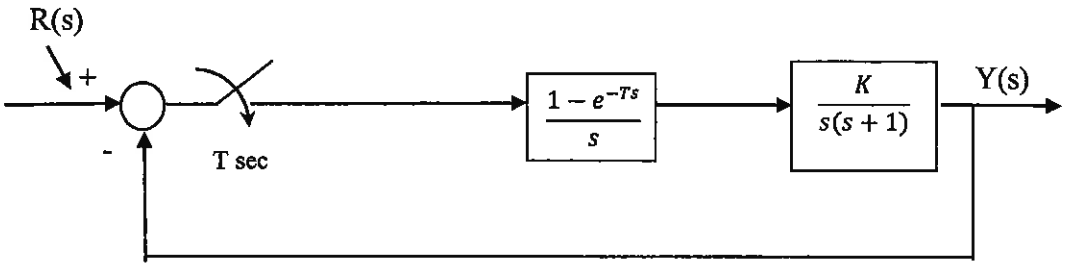

Figure Q4

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APPENDIX

TABLE OF TRANSFORM PAIRS

Time function $f(t); t>0$	Laplace Transform $F(s)$	Z-transform $F(z), T =$ Sampling time
$u_s(t)$	$1/s$	$z/(z-1)$
t	$1/s^2$	$Tz/(z-1)^2$
t^2	$2/s^3$	$T^2 z(z+1)/(z-1)^3$
ε^{-at}	$1/(s+a)$	$z/(z-\varepsilon^{-aT})$
$1-\varepsilon^{-at}$	$a/\{s(s+a)\}$	$z(1-\varepsilon^{-aT})/\{(z-1)(z-\varepsilon^{-aT})\}$
$t\varepsilon^{-at}$	$1/(s+a)^2$	$Tz\varepsilon^{-aT}/(z-\varepsilon^{-aT})^2$
$\sin at$	$a/(s^2+a^2)$	$z\sin aT/(z^2-2z\cos aT+1)$
$\cos at$	$s/(s^2+a^2)$	$z(z-\cos aT)/(z^2-2z\cos aT+1)$
$\varepsilon^{-at}\sin bt$	$b/\{(s+a)^2+b^2\}$	$z\varepsilon^{-aT}\sin bT/(z^2-2z\varepsilon^{-aT}\cos bT+\varepsilon^{-2aT})$
$\varepsilon^{-at}\cos bt$	$(s+a)/\{(s+a)^2+b^2\}$	$(z^2-z\varepsilon^{-aT}\cos bT)/(z^2-2z\varepsilon^{-aT}\cos bT+\varepsilon^{-2aT})$

End of Paper